Volume 15

Study G-III
Job No. G-III-D

STATE OF ALASKA

WILLIAM A. EGAN, GOVERNOR

Annual Performance Report

for

LAKE AND STREAM INVESTIGATIONS

Population Studies of Game Fish and Evaluation of Managed Lakes in the Upper Cook Inlet Drainage

by

Carl J. Kalb

ALASKA DEPARTMENT OF FISH & GAME

James W. Brooks, Commissioner

DIVISION OF SPORT FISH

Rupert E. Andrews, Director
Howard E. Metsker, Chief, Sport Fish Research

TABLE OF CONTENTS

RESEARCH PROJECT SEGMENT

State: ALASKA

Name: Sport Fish Investigations in Alaska.

Project No.: F - 9 - 6

Study No.: G - III

Study Title: LAKE AND STREAM INVESTIGATIONS.

Job No.: G - III - D

Job Title: Population Studies of Game Fish and Evaluation of Managed Lakes in the Upper Cook Inlet Drainage.

Period Covered: July 1, 1973 to June 30, 1974.

ABSTRACT

A lake stocking evaluation study was initiated this job segment. Six rehabilitated lakes were selected to evaluate two strains of rainbow trout, *Salmo gairdneri*, and coho salmon, *Oncorhynchus kisutch*, to develop a standard stocking procedure, designed to allow optimum survival and growth.

Use of the British Columbia stocking curve is explained.

Results of plankton sampling conducted on 12 Matanuska-Susitna Valley lakes are presented. Seasonal variation of plankton abundance in rehabilitated lakes differed from that occurring in untreated lakes.

Water chemistry data for the study lakes are included.

The Johnson Lake rainbow trout survival test was concluded and the lake rehabilitated to remove trout and threespine sticklebacks, *Gasterosteus aculeatus*. Using various sampling methods, a survival estimate of 20-25% was derived for fingerling stocked on September 18, 1973. A possible bias of the initial population estimate, introduced by using marked fish from Fort Richardson, is discussed.

Figures show cost of producing fish to the creel in Johnson Lake range from $0.50 to $0.99 per fish depending on percentage harvest.

A chemical test for determining the presence of rotenone in water is discussed.

A research project was initiated to determine the effect of rotenone on fish food organisms. Assessment of pre-treatment levels of plankton and bottom organisms in Johnson and Memory lakes is described.

RECOMMENDATIONS

1. Determine survival, growth and total yield of fry and fingerling plants of Winthrop, Washington and Ennis, Montana strains of rainbow trout in Long, Seymour, and Short Pine lakes, and of Kodiak, Alaska and Green River, Washington strains of coho in Loon Lake.

2. Stocking of Johnson Lake should be delayed for one year, permitting measurement of biological productivity independent of grazing by a fish population.

3. Christiansen and Marion lakes should be stocked as originally scheduled for 1973.

4. Memory Lake should be stocked with Winthrop, Washington rainbow trout fry at a density of 150 per acre.

5. Limnological sampling should continue on all study lakes described in this job segment except Meirs and Harriet lakes.

OBJECTIVES

1. To determine survival, growth and total yield of stocked game fishes in landlocked lakes of the area.

2. To determine limnological conditions which influence survival and growth of game fishes in lakes of the area.

3. To provide recommendations for the management of stocked lakes and to direct the course of future studies.

TECHNIQUES USED

Plankton samples were collected with a 0.5 m ring-type plankton net of 130 micron mesh size. Permanent sampling stations were set over the maximum depth of the lake. Three vertical hauls were made from 5 m and 30 m or the bottom, whichever was less. The content of each haul was washed into bottles containing 10% formalin solution. Samples were placed in graduated centrifuge tubes and centrifuged for 3 minutes at 2,000 rpm in a model CS International Centrifuge and the volume read to the nearest 0.1 ml.

To facilitate collection of bottom organisms, a permanent transect line was established with stations at 45, 30, 20, 10, 5, and 1 ft. depths on Johnson Lake and 20, 10, 5, and 1 ft. depths on Memory Lake. A Petite Ponar Grab, sampling an area of 91.4 cm^2, was used to take bi-monthly bottom samples from each station.

Grab contents were placed in buckets and then washed through #10 and #20 mesh metal seives. Invertebrate organisms were picked from samples within 24 hours and preserved in 70% isopropyl alcohol.

Survival of the 1972 plant of rainbow trout fingerlings in Johnson Lake was evaluated by introducing a known number of marked trout comparable in size to the population being sampled. The marked trout were retained in a holding pen for 48 hours, released, and allowed to randomly mix in the lake for 13 days prior to sampling.

The population was sampled with 125X6-ft variable mesh monofilament gill nets of 3/4 to 2-inch bar measure. Eight nets were fished for six 24-hour periods.

Qualitative analysis of rotenone in water followed methods developed by the University of Wyoming (Post, 1955).

Fish shocking operations were conducted using an electro-shocking apparatus mounted aboard a 24 ft. river boat. Power was supplied by a Homelite 3,500w portable generator delivering 115 or 230v a-c. A Coffelt Model III-C Variable Voltage Pulsator regulated either a-c, d-c or d-c pulsating current up to 300 v and 10 amps. All wiring was two strand #8 gauge insulated wire with a G.E. foot safety switch placed in the electrode circuit allowing power to be cut instantly in emergencies.

Insulated dip nets were constructed of 10-ft. fiberglass wrapped aluminum poles.

Projecting from a wooden platform on the bow, a 10-ft boom with a 10-ft crosspiece supported three 10-ft electrodes of weighted, flexible conduit. Generally three men would participate in the shocking operations; a motor operator and two dip net operators, one of which controlled the foot safety switch.

All fish measurements were expressed in fork length to the nearest millimeter and in weight to 0.1 lb.

Water samples were collected with a Kemmerer water sampler and dissolved oxygen levels were determined by PAO titration. Alkalinity, hardness, and pH were determined using the Hach AL-36-WR field test kit.

Water temperature was measured with a YSI Tele-thermometer and conductivity with a Hach Model 2510 conductivity meter.

FINDINGS

Lake Stocking Evaluation Study

To date, little information exists that would assist a managing biologist in deciding what density and size of fish should be planted in managed or previously unmanaged Alaskan lakes.

Such decisions have been based primarily on considerable guesswork and the current practices of evaluating success of stocking programs in our managed lakes with gill nets, electro-fishing, and angler catch data.

A project was therefore initiated to develop, from physical, biological, and limnological information, a standard stocking procedure designed to allow optimum survival and growth of game fish in a lake of known characteristics.

The preliminary phase of this project will be directed toward general objectives so after guidelines have been established more definitive studies may precede.

Objectives of the 1973-1974 segment have been defined as:

1. Comparison of fry and fingerling plants.

2. Evaluation of Winthrop, Washington and Ennis, Montana rainbow trout, Salmo gairdneri, strains and Kodiak, Alaska and Green River, Washington coho salmon, Oncorhynchus kisutch, strains.

3. Determine the survival, growth and total yield of game fish in lakes of varying limnological characteristics.

4. Evaluation of British Columbia stocking curve for converting numbers of larger fish to equivalent numbers of smaller fish.

The initial stocking schedule was developed to approximate current production capabilities of the Fire Lake Hatchery yet be flexible enough to adjust to year-to-year growth variations among different strains of fish. Rainbow trout hatched from Winthrop, Washington and Ennis, Montana egg sources were selected for comparison because these strains are predominantly used by the hatchery. As Ennis rainbow trout are mid-winter spawners, eggs are available to the hatchery at an early date, allowing a greater growth period compared to the Winthrop strain, which are spring spawners. Resulting size differences avail themselves well to an evaluation of fry and fingerling plants.

Five lakes, Marion, Seymour, Christiansen, Long, and Short Pine, were selected to evaluate the survival, growth, and total yield of the rainbow trout strains. These lakes, all rehabilitated in fall of 1972, are described in Table 1.

When stocking lakes with Winthrop fry and Ennis fingerling, it was necessary to equate numbers of fry to numbers of fingerling from the British Columbia

TABLE [illegible]. Morphometric Data for Study Lakes in the Matanuska-Susitna Valleys.

Lake	Location	Surface Area (Acres)	Maximum Depth (Ft.)	Mean Depth (Ft.)	Volume Acres (Ft.)	Shoreline Distance (miles)	Littoral[1] Area (%)	Elevation (ft.)
Seymour	T18N, R2W Sec 8-10 9-33	229	19	7	1,605	3.[illegible]	88	300
Christiansen	T26N, R4W Sec 29	179	82	22	3,961	4.6	47	200
Loon	T18N, R3W Sec 36	108	17	10	1,133	1.9	73	270
Marion	T16N, R4W Sec 1	113	42	21	2,324	2.7	33	150
Memory	T18N, R1W Sec 22-23 26-27	83	21	7	607	2.4	88	450
Long	T17N, R1E Sec 13	74	55	26	1,945	2.4	28	85
Johnson	T17N, R1E Sec 14	40	41	20	806	1.2	46	95
Short Pine (Kenai Peninsula)	T7N, R11W Sec 8, 17	52	36	17	890	---	30	125

[1] Littoral area is that portion of lake less than 15 feet deep.

stocking curve (Smith, et al., 1969). Planting densities of 150 and 300 fish per surface acre were based on an equivalency of 107 fish per lb. The stocking schedule devised for 1973 is summarized in Table 2.

Application of the stocking curve may be explained using figures calculated for Long Lake (74 surface acres), which received Winthrop fry and Ennis fingerling at a combined theoretical density of 300 fish per surface acre.

At the time of stocking, Ennis fingerling had attained a size of 107 per lb., and the fingerling compliment of the plant, at 150 per acre, was 11,100 fish.

Winthrop fry measured 1,178 per lb. so it had to be determined what numbers of fry must be planted, based on an equivalency of fingerling 107 per lb. to produce catchable size adults approximately equal in number to that produced by a fingerling plant of 150 per acre.

Using sizes of the two strains of fish, a value is obtained from the stocking curve which converts the number of larger fish into equivalent numbers of smaller fish. This value is 3.75 and when multiplied times 11,100 fish gives 41,700 fish, the number of fry needed.

Christiansen Lake was to be the second lake stocked in a similar manner with both strains of rainbow trout but at a combined density of 150 fish per acre. The lake remained toxic until late fall and the plant was postponed, however.

Two additional lakes were selected to evaluate each trout strain in a non-competitive situation. Seymour Lake was stocked with 257,700 Winthrop fry which is equivalent in number to a fingerling plant at 300 fish per acre. Marion Lake was to receive 33,900 Ennis fingerling, however, this plant was postponed when the lake did not completely detoxify until late fall.

Short Pine Lake, located on the Kenai Peninsula, was stocked with Ennis and Winthrop strains of approximately equal size. By isolating a group of Winthrop fry early in the summer and promoting accelerated growth, it was possible to approximate the size of Ennis fingerling, allowing comparison of both stocks under similar conditions. Each stock composed half of the total plant of 15,600 fish at a combined density of 300 per acre. At the time of planting Winthrop fish measured 125 per lb and the Ennis group were 112 per lb. To make identification possible, both groups received opposing fin clips.

A sixth lake was selected to conduct a similar evaluation of two coho stocks. Equal numbers of salmon from Kodiak, Alaska, and Green River, Washington, measuring 143 and 133 per lb., respectively, were planted in Loon Lake at a density of 300 per acre. Stocks are identified by left and right ventral fin clips. This comparison will hopefully provide information on the growth and survival of coho in a landlocked lake and the suitability of out-of-state stocks in Alaskan waters.

In the spring of 1974, survival and growth data will be determined for each lake population. Fish will be captured using gill nets and/or electroshocker and Bailey's modification of the Peterson method will be used to estimate population size.

TABLE 2 Lake Stocking Evaluation Study, Stocking Schedule 1973.

Lake	Date Stocked	Strain[2]	Size (Fish/lb.)	Stocking Density[3] (Fish/Acre)	Stocking Proportion[4] (Fry/Fingerling)	Number of Fish
			RAINBOW TROUT			
Long	7/ 6/73	W	1,178	300	3.75/1	41,700
		E	107			11,100
Christiansen[1]		W	1,178	150	3.75/1	50,350
		E	107			13,400
Seymour	7/ 6/73	W	1,178	300	1/0	257,600
Marion[1]		E	107	300	0/1	33,900
Short Pine	7/26/73	W	125	300	1/1	7,800
		E	112			7,800
			COHO SALMON			
Loon	8/ 8/73	K	143	300	1/1	16,270
		GR	133			16,135

1 Lake remained toxic - stocking postponed.
2 W - Winthrop, Wn.
E - Ennis, Mont.
K - Kodiak, Ak.
GR - Green River, Wn.
3 Density based on 107 fish per pound.
4 Developed from British Columbia stocking curve (Smith, et al. 1969).

information derived from this first evaluation will be used to develop a more definitive stocking schedule; one which will eventually establish the necessary guidelines for subsequent lake plants.

Limnological Sampling

As part of the stocking evaluation, a study in progress attempts to establish physical and limnological parameters that encompass variables influencing survival and growth. If the combination of these variables represent productivity of a lake, then data expressing degree of productivity would provide the biologist with factual basis for relating stocking intensity to a specific body of water.

A basic limnological method available for indicating the general nutritive condition of a lake is measurement of plankton abundance. Initiating a plankton sampling program on June 1, 1973, we hoped to establish (1) the relative plankton abundance in each study lake, (2) an identification of major zooplankton species present during the summer field season, and (3) to eventually develop an index relative to the biological productivity of each lake.

Samples were taken approximately every two weeks from each study lake and from Johnson and Memory lakes. Four additional lakes, Lucille, Matanuska, Harriet and Meirs, were sampled monthly.

A summary of plankton volumes determined for each lake during the sampling season is given in Table 3. When plankton occurrence in a series of hauls averaged less than 0.1 ml it was recorded as simply 0.1 ml. This lack of plankton commonly occurred during early summer in lakes which were chemically treated the preceding fall.

Large plankton volumes were captured in Matanuska Lake on July 3, 1973, during a rich plankton bloom. Sampling error developed when the plankton net became clogged with plankters, affecting filtering efficiency, and a larger plankton volume (42.5 ml) was obtained from the 5 m haul than the haul from the bottom (38.2 ml).

Examination of plankton volumes for each sampling date suggests seasonal variation of plankton abundance in lakes rehabilitated in the fall, 1972, differed from that occurring in untreated lakes. In Figure 1, it appears there is a general increase in plankton standing crop of treated lakes with the progression of summer, while in Figure 2, the highest plankton levels appear in early summer and tend to decrease with time. Two exceptions are Memory Lake in Figure 2, which had a very low total plankton volume and Marion Lake whose total volume was so low it was not included in Figure 1.

Seasonal plankton variation of untreated lakes is a particularly noteworthy occurrence. High plankton volumes measured in June and early July are undoubtedly correlated to high nutrient levels and extended solar radiation. The abrupt decline of volume in late summer, though, is contributed to utilization of available nutrients, restriction to circulation

TABLE 3 Summary of Centrifuged Plankton Volumes for the Project Lakes, 1973.

Lake	Depth of Haul (m)	Total Centrifuged Volume (ml)	Seasonal Average (ml)	Range (ml)
Matanuska	5	59.9	12.0	0.9 - 42.5
	22	67.8	13.6	1.2 - 38.2
Meirs	5	44.4	8.8	2.7 - 21.4
	18	63.5	12.7	3.1 - 21.8
Harriet	5	26.6	5.3	2.1 - 18.0
Johnson	5	14.9	2.1	0.5 - 4.6
	10	31.0	4.4	2.1 - 8.1
Long	5	9.6	1.1	0.1 - 2.0
	14	29.4	3.3	1.0 - 6.1
Lucille	5	14.2	2.8	0.3 - 6.1
Loon	3	6.3	0.8	0.1 - 2.8
Seymour	4	3.6	0.5	0.1 - 0.9
Short Pine	5	3.0	0.4	0.1 - 2.1
	8	3.6	0.5	0.1 - 2.1
Christiansen	5	0.1	---	0.1
	20	2.4	0.3	0.1 - 0.9
Memory	3.5	1.84	0.3	0.1 - 0.7
Marion	5	0.2	0.1	0.1 - 0.1
	10	0.6	0.1	0.1 - 0.3

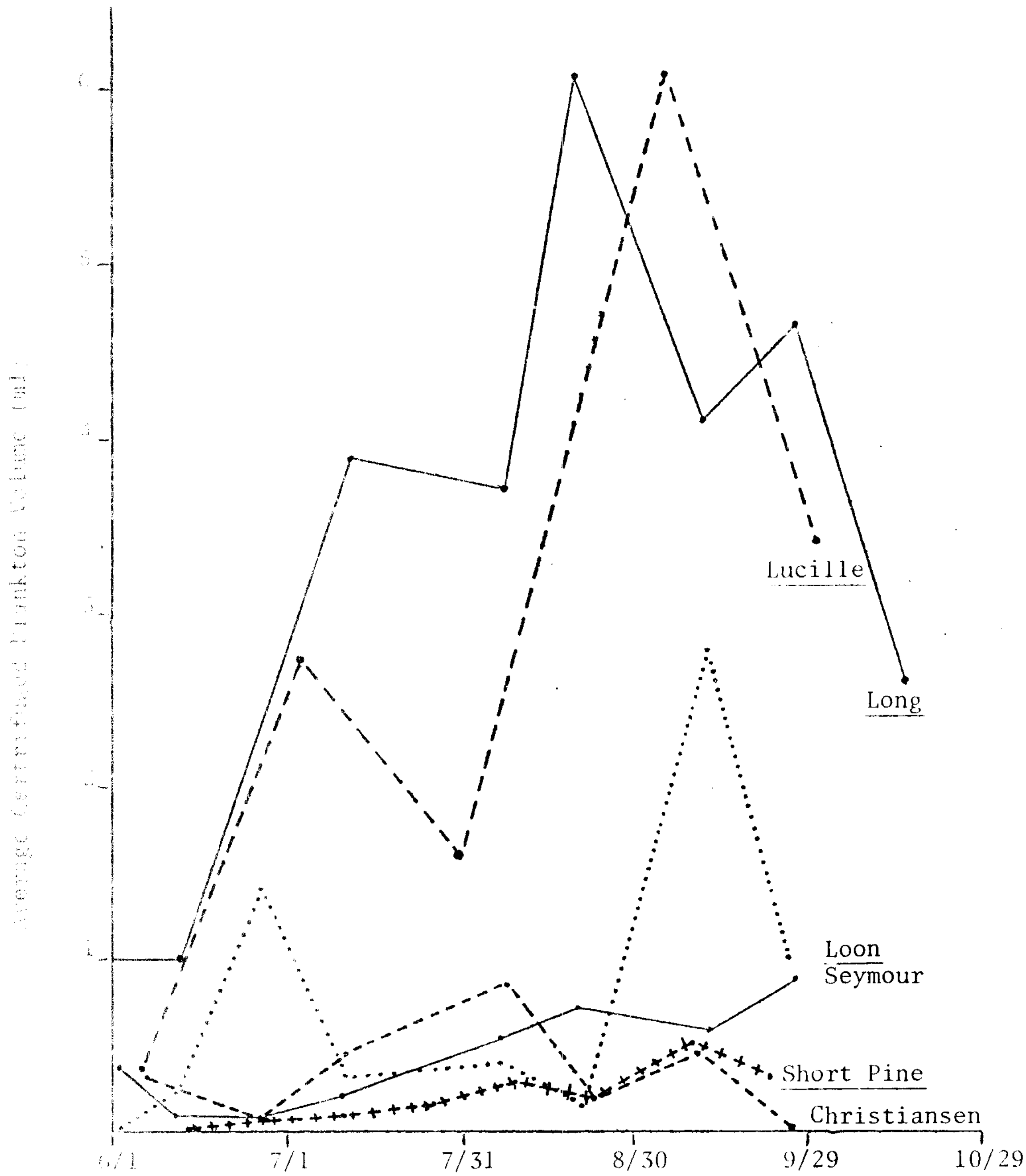

FIGURE 1. 1973 Plankton Volume Summary of Lakes Rehabilitated Fall, 1972.

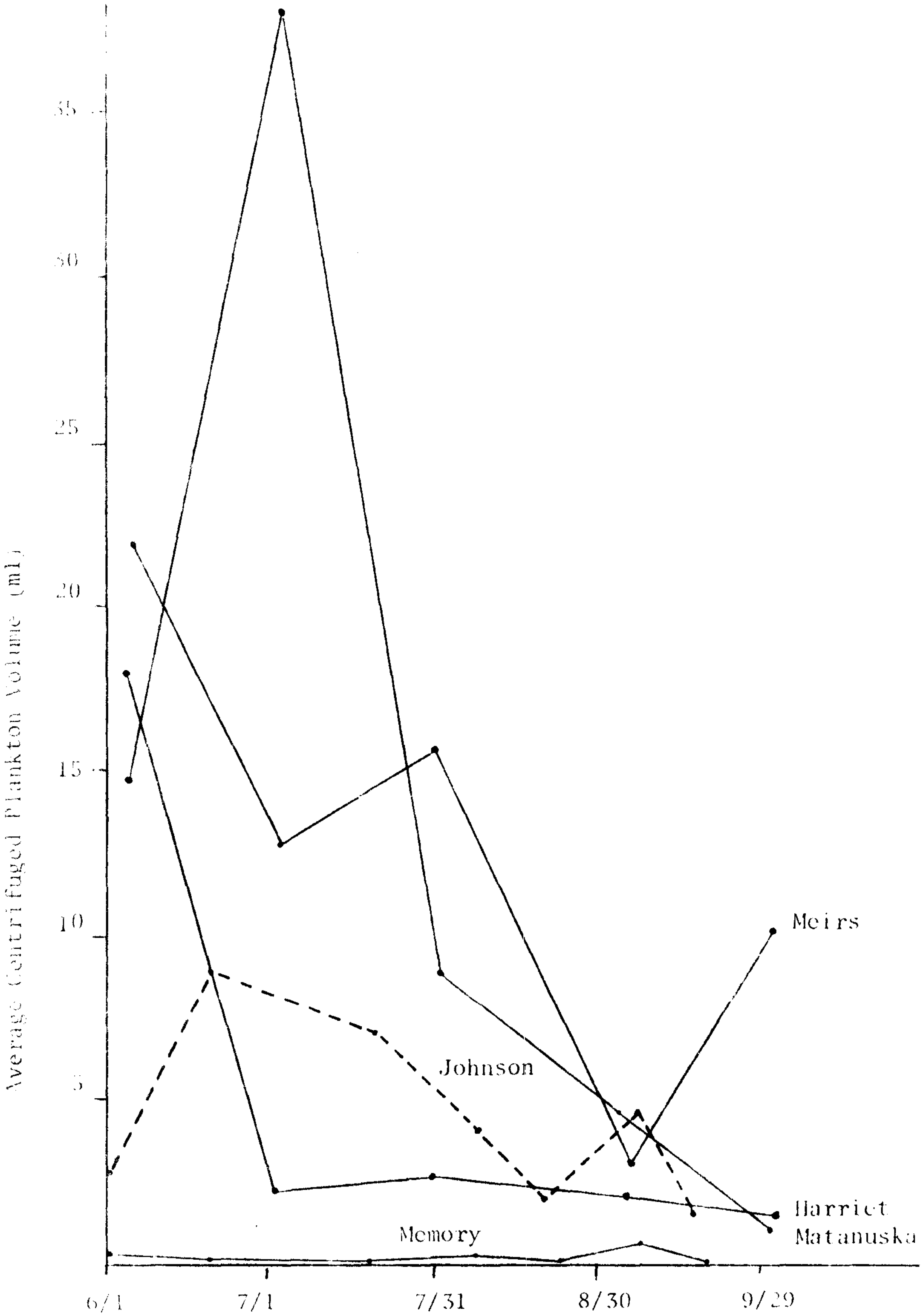

FIGURE 2 1975 Plankton Summary of Untreated Lakes.

of nutrient regeneration into the upper water layers by thermal stratification, and, to a lesser degree, influence by grazing on the plankton standing crop by substantial fish populations.

Seasonal plankton variation in the seven lakes chemically treated during the fall of 1972 appears to be the inverse of variation in untreated lakes. Low plankton abundance throughout the early sampling period and subsequent increase as summer progressed, suggest plankton productivity was retarded by application of rotenone.

Previous investigations have verified the detrimental effect of rotenone on plankton species, especially cladocerans and copepods. Kiser, et al., (1963) found abundance of open-water zooplankton species severely reduced in two lakes treated with 0.5 and 1 ppm concentrations of 5% rotenone. Zooplankton species were not completely eliminated but did not begin to return to pre-treatment levels until five weeks after the water had become non-toxic to fish.

A study by Brown and Ball (1943) showed a disappearance of cladocerans and copepods for as long as five weeks in a lake treated at 0.5 ppm of 5% rotenone. M. W. Smith (1939) observed the disappearance of open water cladocerans and copepods for several months, with an eventual return.

Relative productivity of a lake may be a critical factor influencing the duration of planktonic inactivity after treatment with rotenone. In Lucille and Long lakes (Figure 1), which are considered productive lakes, plankton volumes increased after several weeks; however, the increase in volume was slower, and of a lesser magnitude in the remaining lakes, which are of low productivity.

Identification of plankton samples to date has been delayed and will be completed in the coming study period. Zooplankton will be identified to genus and species when possible and the percentage composition of species determined for each sample. Cursory examination, however, has shown the dominant species to be members of Cladocera, Copepoda, Rotifera, and Ciliophora.

Selection of zooplankton as a food item by rainbow trout may be greatly influenced by size of the plankton organism. Brynildson and Kempinger (1973) in a study of growth, production, and food of two species of trout, found planktonic crustaceans 1 mm and larger the staple food of brown and rainbow trout less than 16 inches in length. No stomachs contained plankton less than 1 mm in size.

Galbraith (1967) also reports rainbow trout were very size selective and usually consumed Daphnia only 1.3 mm in size and greater.

Due to this size selective relationship, particular attention will be paid to size of planktonic crustaceans by recording the percentage of plankters greater than 1 mm in size.

When sufficient data are compiled, a plankton index system will be developed that will attempt to relate and compare general productivity of managed lakes in the Matanuska-Susitna valleys. No such system has yet been decided upon as further investigation is warranted.

Water Chemistry

Water chemistry determinations were made on seven study lakes in the Matanuska-Susitna valleys.

Dissolved oxygen sampling began in May, 1973, and continued on a monthly basis to the present date. Water chemistry samples were taken bimonthly until freeze-up, and then on a monthly schedule. Temperature profiles were recorded bimonthly in conjunction with each sampling date.

Table 4 presents dissolved oxygen and temperature determinations for four selected samples from each lake, representing typical conditions generally existing in spring, summer, fall, and winter.

Sufficient oxygen for rainbow trout persists throughout the year in all study lakes. Due to substantial wind stress, the lakes experienced turnover twice during the year, except Christiansen Lake, which appears to have had only a fall turnover.

Table 5 is a summary of water chemistry characteristics for the seven Valley lakes and Short Pine Lake on the Kenai Peninsula. Lakes are ranked in order of their relative nutrient values which vividly illustrates variation in productivity of the study lakes. Marion Lake is considered one of the least productive managed lakes in the Matanuska Valley.

Johnson Lake Rainbow Trout Survival Tests

A research program designed to determine survival rates of stocked rainbow trout when in competition with threespine sticklebacks, *Gasterosteus aculeatus*, was culminated this job segment after four years of study.

Since a comprehensive report of the previous three years of testing was described by Watsjold (1973) it was unnecessary to duplicate those findings.

Estimates of survival for each year were made in the spring following stocking when age I trout would enter the fishery. An examination of data available from the 1970, 1971, and 1972 survival estimates infers maximum survival occurs when larger fish are stocked at lower densities. A summary of population and survival estimates for the three years of testing is given in Table 6.

Based on the above premise, it was decided to make a final plant using the largest-sized fingerling feasibly available from the Fire Lake Hatchery at a medium stocking density. This plant was made on August 8, 1972, comprising 7,875 fingerling trout at 34 per lb. and a density of 200 per acre.

TABLE 3. Summary of Water Chemistry Characteristics for Eight Study Lakes, 1973-74.

Lake	Sampling Period	Mean pH	pH Range	Total Alkalinity As $CaCo_3$ (ppm) Mean	Total Alkalinity As $CaCo_3$ (ppm) Range	Total Hardness as $CaCo_3$ (ppm) Mean	Total Hardness as $CaCo_3$ (ppm) Range	Conductivity (micromhos/cm) Mean	Conductivity (micromhos/cm) Range
Long	5/11/73- 2/21/74	8.7	8.6 - 8.8	136.8	119.7- 153.9	131.7	119.7- 153.9	240	200-260
Johnson	5/16/73- 2/26/74	8.4	7.5 - 8.7	98.3	76.0- 119.7	83.8	68.4- 85.5	143	126-172
Seymour	5/11/73- 2/25/74	7.8	7.1 - 8.7	74.1	68.4- 85.5	68.4-	51.3- 85.5	104	88-132
Memory	5/31/73- 2/26/74	7.5	6.8 - 8.2	43.5	34.2- 51.3	34.2	34.2	49	42-62
Christiansen	5/18/73- 1/28/74	7.5	7.0 - 8.4	49.6	34.2- 68.4	34.2	34.2	47	47-61
Loon	5/11/73 2/25/74	7.1	6.7 - 7.5	28.8	17.1- 51.3	18.7	17.1- 34.2	17.1	13.4-23
Short Pine	6/14/73- 9/23/73	7.7	7.3 - 8.0	17.8	13.7- 34.2	32.2	17.1- 51.3	---	---
Marion	5/11/73- 2/25/74	7.0	6.7 - 7.2	29.9	17.1- 51.3	17.1	17.1	12.4	8-24

A total of 126 gill-net hours from May 10 to May 11, 1973, captured 167 trout from the 1972 plant and 20 trout from prior plants. Mean size of the 1972 plant was 189 mm in length and 0.17 lb. in weight. Based on this sample a matching plant of 300 adipose-clipped rainbow trout, averaging 185 mm in length and 0.17 lb., were stocked on May 23, 1973. Prior to release, the marked fish were held for 48 hours to check for handling mortality.

The matching plant was allowed to distribute randomly in the lake for 11 days before intensive gill netting began. From June 4 through June 13, 1973, a total of 1,110 net-hours captured the following:

Matching plant - 53 fish
1972 plant - 368 fish
Prior plants - 44 fish

The population estimate of the 1972 plant was calculated using Bailey's modification of the Petersen method (Ricker 1958), written as $N = \frac{M(C+1)}{R+1}$.

Using the notation of Ricker:

N = Estimate of population size.
M = Number of marked fish in population (300).
C = Total catch of sample (421).
R = Number of marked fish in sample (53).

The 95% confidence interval of the population estimate (N) was obtained by calculating the 95% confidence limits for R and substituting in the above equation.

The population estimate and 95% confidence interval of the 1972 plant are as follows:

Population Estimate	Survival	95% Confidence Interval Estimates	Survival
2,344	30%	1,720-2,965	22%-38%

The 1972 plant of rainbow trout in Johnson Lake marked the completion of the first phase of study in stickleback waters, and the lake was chemically rehabilitated in the fall of 1973. In the second phase of study, rainbow trout will be re-introduced in 1975 to assess survival, growth, and total yield in a stickleback-free environment.

As the remaining trout were to be eradicated, it was decided to evaluate whether gill-net sampling bias would introduce error in the survival estimate by utilizing other sampling techniques for comparison.

Hook and line sampling began immediately after termination of gill netting on June 13, 1973, and continued for comparative purposes until July 8, 1973. During this period, 56 fish from the 1972 plant and 30 marked fish were caught. Marked fish in this sample comprised 35% of the total catch, representing a higher percentage of recovery than the 12.5% recovered by gill net sampling.

A boat mounted electro-shocker operated with little success from September 5 to September 13, 1973. A total of approximately 11 hours of shocking captured only 16 trout, 25% being marked fish. The small sample may be attributed to electrical problems with the shocking unit and physical characteristics of Johnson Lake.

On September 18, 1973, Johnson Lake was chemically treated at 0.6 ppm Pro-Noxfish. Immediately prior to treatment, on September 17, four gill nets were set for 24 hours. Twenty-four percent of the 54 fish captured were adipose clipped.

For several days after treatment, poisoned fish were collected from the surface and lake bottom. From the total of 168 fish collected, 25% were marked fish.

The results of all sampling methods used in Johnson Lake in 1973 are summarized in Table 7.

Causes underlying differences in the proportion of marked fish from the various sampling methods are inadequately understood; however, the author believes at this time the following conjectures to be the most plausible explanation.

To obtain a valid population estimate of the 1972 plant of rainbow trout it was necessary to stock adipose clipped fish of approximately equal size. As there were no available means to obtain live fish for marking from the lake population, the matching plant was taken from the "catchable" rainbow trout held in the Fort Richardson cooling ponds. Fish in these ponds are frequently seined for sorting purposes, so undoubtedly become conditioned to the presence and use of nets. It is possible this negative conditioning to nets, plus clear-water conditions and long daylight hours at the time of sampling from June 4 to June 13, led to avoidance of gill nets by marked fish. Such an avoidance to nets would result in a low proportion of marked fish in the catch and contribute to an over-estimate of the total population.

It appears gill-net avoidance was also exhibited by the lake population of rainbow trout. In 1970 (Redick, 1971), a marked reduction in catch occurred after the third sampling day in Johnson Lake, at which time 80% of the total catch had been already netted. Watsjold (1973), noted a similar reduction in catch after the second day in 1972.

In 1973, a reduction in gill-net catch again occurred. Table 8 presents catch data by day for 1973, showing that after the first day 45% of the fish had been captured, and 62% by the second day, even though a large fish population remained in the lake.

TABLE 6 Summary of Rainbow Trout Population and Survival Estimates in Johnson Lake for 1970, 1971, and 1972.

Year Stocked	Stocking History: Number	Stocking History: Per lb.	Stocking History: Per Acre	Estimates after one year: Population Size	Estimates after one year: Survival
1969	2,496	85	62	606	24.3%
1970	7,446	349	183	No Fish Recovered	
1971	4,419	88		126	2.9%
	3,628	96	300[1]	128	3.5%
	3,971	333		161	4.1%

[1] Combined density

TABLE 7 Results of Sampling Methods Used in Johnson Lake, 1973.

Method	Total Catch	Marked Fish: Number Caught	Marked Fish: % of Total Catch
Gill Netting (May)	421	53	12.5%
Hook and Line	86	30	35%
Electro-shocking	16	4	25%
Pre-treatment gill netting	54	13	24%
Post-treatment collection	168	42	25%

TABLE 8 Gill Net Catch Data for Johnson Lake, 1973.

Date	No. Nets Fished	Catch	Catch Rate Fish/Net Hour
6/ 4- 5	8	191	1.15
6/ 5- 6	8	72	0.38
6/ 6- 7	8	52	0.27
6/ 7- 8	8	37	0.19
6/11-12	8	38	0.22
6/12-13	8	31	0.17
TOTAL		421	

These data indicate a definite learning process by the lake population directed to avoidance of nets and offers further credence to the explanation of factors contributing to a low proportion of marked fish.

At the time gillnetting was completed on June 13, 1973, a disproportionate ratio of marked fish existed in Johnson Lake, as a larger proportion of the 1972 plant had been removed by sampling. This would account for the high proportion of marked fish (35%) caught by hook and line sampling. It is also possible that conditioning of the matching plant in the Fort Richardson cooling ponds to surface feeding and human activity also influenced their susceptibility to capture by hook and line methods.

The percentages of marked fish in samples obtained by electro-shocking, pre-treatment gill netting and post-treatment collection were essentially similar (Table 7). The 25% proportion of marked fish in the sample obtained by random collection of poisoned fish after chemical treatment should be the most unbiased representation of the actual fish population existing in the lake at that time. It is assumed that the pre-treatment gill-net sample was also relatively unbiased as the mean size of fish captured ($\bar{X}$=269 mm) was identical to the collection sample.

Combining data from the pre-treatment netting and post-treatment collection, and again applying the modified Petersen method, an estimate is derived of population size at the time of chemical treatment on September 18, 1973. The estimate of 851 trout, and a 95% confidence interval of 706 to 1,105, is considered a reasonably accurate and unbiased estimate.

The known number of unmarked fish removed by sampling methods from May 11 to September 17, 1973, is 622 fish. When this figure is added to the final population estimate of September 18, 1973, the sum of 1,473 is an estimate of the Johnson Lake rainbow trout population immediately prior to sampling on May 11, 1973. This estimate, representing 19% survival, may be a low estimate since natural mortality occurring during the four month period was not accounted for.

Assuming the gill net sample of June 5 to 13, 1973 to be biased, the initial survival estimate of 30% is undoubtedly an overestimate. The 1972 rainbow trout plant in actuality had a survival of approximately 20-25%.

Biomass of age I rainbow trout in Johnson Lake on June 11, 1973, was calculated by multiplying average individual weight by estimated size of the fish population calculated for 20% and 25% survival. The results are presented in Table 9.

Using the higher survival estimate, fingerling stocked in 1973 show an increase of 2.6 lb. per surface acre or a 31% gain in biomass.

In-hatchery production cost for salmon and trout at Fire Lake Hatchery was recently made available (J. Wallis, unpublished data). This cost scheduling makes it possible to compute the cost of developing catchable rainbow trout in Johnson Lake.

Assuming the estimated value per fish at an average size of 34 per lb. is \$0.12, plus approximately \$30 transportation cost, the total expense of planting 7,875 fingerling was \$975. The percentage of harvest of age I fish would vary with fishing intensity, so estimated value to the creel per fish was calculated for 100%, 75%, and 50% harvest. These costs are detailed in Table 10.

In assimilating information provided by the past years' data, it becomes apparent that to obtain acceptable survival and growth in stickleback-infested waters, rainbow trout must be stocked at large size and low density. Actual stocking rates for stickleback-inhabited lakes in other areas will depend upon factors specific to the lake in question; however, it is recommended that rainbow trout be stocked at 35-85 fish per lb., and a density of 100-150 fish per acre.

The question of whether to stock hatchery-reared salmonids in stickleback-infested waters is yet unresolved. It is hoped this study will provide the guidance for research in other areas of the State.

The second phase of the Johnson Lake research program beginning in 1975 will attempt to evaluate enhancement to rainbow trout production through rehabilitation, and the comparable cost to the sportsman.

Determination of Rotenone in Water

The chemical test for determination of rotenone in water (Post, 1955) is considered primarily a qualitative test, its accuracy supposedly not dependable enough for quantative work. The simplicity of the method and low cost of glassware and chemicals, however, make it possible to estimate rotenone concentrations during chemical rehabilitation operations or to check for residual amounts of rotenone before placing live test fish in a lake the following spring.

If Pro-Noxfish or another 2.5% rotenone carrier has been used as the toxicant, it is recommended that a 1-liter sample of water be drawn rather than the 500 ml suggested by Post. This insures that color intensity will compare with those developed for the Wyoming Game and Fish Commission color chart.

Since rotenone concentration is estimated by visual inspection of a color developed after completion of a series of laboratory operations, there is often uncertainty of the sample's concentration. In such instances, a standard dilution should be prepared for comparative purposes.

The author believes this method to be reasonably accurate allowing rotenone determination to $\pm$ 0.2 ppm. When the concentration reaches 0.2 ppm or lower, it may only be possible to check whether rotenone is present or not.

TABLE 9 Biomass of Rainbow Trout in Johnson Lake, June, 1973.

No. and Lbs. of Fish Stocked 1972				Biomass One Year After Stocking			
				Total Lbs.		Lbs/ Surface Acre	
No. Stocked	No. Per Lb.	Total Lbs. Stocked	Surface Acre Stocked	20%	25%	20%	25%
7,875	34	232	5.8	268	335	6.7	8.4

TABLE 10 Estimated Cost to the Creel of Rainbow Trout in Johnson Lake.

Stocking Cost		Cost to the Creel (% Harvest)		
Total	Per Fish	100%	75%	50%
$975	$0.12	$0.50	$0.66	$0.99

Environmental Impact of Rotenone Treatment on Two Matanuska Valley Lakes

A research project was initiated to determine the detrimental effect of rotenone treatment on food organisms utilized by game fish species, and the ability of those organisms to re-establish following detoxification.

Studies on the effect of emulsified rotenone on food organisms have been conducted by other researchers (Kiser, et al., 1963; Brown and Ball, 1943; Smith, 1939) who have observed a deleterious effect on planktonic and bottom organisms. These field studies were conducted in areas where favorable climatic conditions promoted a rapid detoxification of the lakes. In Alaska, though, the present practice is to chemically treat lakes just before formation of winter ice cover, reducing the deterioration rate of rotenone. It is unknown if the prolonged toxicity more severely affects re-establishment of food organisms in the short productive season of northern lakes.

The project will focus on two lakes in the Matanuska Valley. Johnson Lake is considered a moderately rich lake while Memory Lake is much less fertile. Both lakes supported populations of threespine sticklebacks prior to rehabilitation and Johnson Lake also contained rainbow trout. The morphometric characteristics of the two lakes are detailed in Table 1.

On September 18 and 19, 1973, Johnson and Memory lakes were treated with 0.6 and 0.8 ppm Pro-noxfish, respectively. Project design calls for assessment of pre-and-post-treatment levels of plankton, bottom organisms, and water chemistry, to continue for at least two years from the date of rehabilitation. Duration of toxicity will be determined using the chemical test for rotenone and live fish suspended in cages.

Water and plankton sampling began on May 31, 1973. Pre-treatment plankton volumes are presented in Table 3 and a summary of water chemistry is given in Table 5.

Bottom sampling, using a Petite Ponar bottom grab, began on July 17, 1973, and the samples are currently being identified by the Institute of Water Resources, University of Alaska, Fairbanks.

Both plankton and bottom sampling were terminated when the lakes were rehabilitated and will resume after break-up of the winter ice cover.

Memory Lake will be stocked with rainbow trout in the summer of 1974; however, no fish will be introduced in Johnson Lake until 1975, so measurement may be made of biological productivity, independent of grazing by a fish population.

LITERATURE CITED

Brown, C. J. C., and R. C. Ball. 1942. An Experiment in the Use of Derris Root (Rotenone) on the Fish and Fish-Food Organisms of Third Sister Lake. Trans. Am. Fish. Soc., 72:267-284.

Brynildson, O. M., and J. J. Kempinger. 1973. Production, Food and Harvest of Trout in Nebish Lake, Wisconsin. Wis. Dept. Nat. Resour. Tech. Bull. Vol. 56, 20 pp.

Galbraith, M. G. 1967. Size-Selective Predation on Daphnia by Rainbow Trout on Yellow Perch. Trans Am. Fish. Soc. 96 (1): 1-10.

Kiser, R. W., J. R. Donaldson and P. R. Olson. 1963. The Effects of Rotenone on Zooplankton Populations in Freshwater Lakes. Trans. Am. Fish. Soc. 92 (1): 17-24.

Post, G. 1955. A Simple Chemical Test for Rotenone in Water. Prog. Fish-Culturist, 17 (4): 190-191.

Redick, R. 1971. Inventory, Cataloging and Population Sampling of the Sport Fish and Sport Fish Waters of the Cook Inlet Drainage. Federal Aid in Fish Restoration, Annual Report of Progress, 1970-1971, Project F-9-3, 12:65-94.

Ricker, W. E. 1958. Handbook of Computations for Biological Statistics of Fish Populations. Bull. Fish. Res. Bd. Canada, Vol. 119:330 pp.

Smith, M. W. 1939. Copper Sulfate and Rotenone as Fish Poisons. Trans. Am. Fish. Soc. 69:141-157.

Smith, S. B., T. G. Halsey, G. E. Stringer and R. A. H. Sparrow. 1959. The Development and Initial Testing of a Rainbow Trout Stocking Formula in British Columbia Lakes. Fish. Mgt. Rpt. B. C. Fish and Wildlife Branch Vol. 60, 18 pp.

Watsjold, D. 1973. Population Studies of Game Fish and the Evaluation of Managed Lakes in the Upper Cook Inlet Drainage. Federal Aid in Fish Restoration, Annual Report of Progress, 1972-1973. Project F-9-5, Volume 14; 17 pp.

Prepared by:	Approved by:
s/Carl Kalb Fishery Biologist	s/Howard E. Metsker Chief, Sport Fish Research
	s/Rupert E. Andrews, Director Sport Fish Division